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IS 10776-3 (1984): Methods of measurement of electro-acoustical characteristics of hearing aids, Part 3: Additional measurements for hearing aids with automatic gain control circuits [LITD 7: Audio, Video and Multimedia Systems and Equipment]



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“Knowledge is such a treasure which cannot be stolen”



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IS : 10776 ( Part 3 ) - 1984

*Indian Standard*

METHODS OF  
MEASUREMENT OF ELECTRO-ACOUSTICAL  
CHARACTERISTICS OF HEARING AIDS  
PART 3 ADDITIONAL MEASUREMENTS FOR HEARING  
AIDS WITH AUTOMATIC GAIN CONTROL CIRCUITS

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**INDIAN STANDARDS INSTITUTION**  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# Indian Standard

## METHODS OF MEASUREMENT OF ELECTRO-ACOUSTICAL CHARACTERISTICS OF HEARING AIDS

### PART 3 ADDITIONAL MEASUREMENTS FOR HEARING AIDS WITH AUTOMATIC GAIN CONTROL CIRCUITS

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Emeritus Scientist  
National Physical Laboratory ( CSIR )  
New Delhi

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Emeritus Scientist

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# *Indian Standard*

## METHODS OF MEASUREMENT OF ELECTRO-ACOUSTICAL CHARACTERISTICS OF HEARING AIDS

### PART 3 ADDITIONAL MEASUREMENTS FOR HEARING AIDS WITH AUTOMATIC GAIN CONTROL CIRCUITS

#### 0. FOREWORD

**0.1** This Indian Standard ( Part 3 ) was adopted by the Indian Standards Institution on 16 February 1984, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

**0.2** This standard applies to hearing aids of any type with automatic gain control ( AGC ) circuits.

**0.3** This standard includes devices which have compression and/or limiting properties with respect to the envelope of the input signal. Devices which control the long-term average output level are also included:

- a) AGC is employed to obtain compression, or the reduction of the dynamic range of the sound at the output, with the object of preserving the integrity of the input waveform.
- b) AGC circuits instead of clipping devices are often used for limiting purposes.

A limiting effect occurs when the input/output characteristic flattens out at higher input levels. Limiting action is mainly used as a means of preventing excessive output sound from the hearing aid from reaching the listener's ear.

**0.4** This standard does not include:

- a) Expanders.
- b) Clipping devices, which cut off the signal peaks above a certain level; such devices differ basically from AGC circuits, which, in a steady state, tend to preserve the waveform of the input signal.

NOTE — An AGC circuit with very short recovery time may cause considerable distortion, especially in the low-frequency range. This should be given special attention.

## **IS : 10776 ( Part 3 ) - 1984**

**0.5** The methods of measurement of electro-acoustical characteristics of hearing aids are being covered by a series of standards consisting of the following individual parts:

- Part 1 General measurements for air-conduction hearing aids
- Part 2 Additional measurements for hearing aids with induction pick-up coil input
- Part 3 Additional measurements for hearing aids with automatic gain control circuits
- Part 4 Measurements of characteristics of hearing aids with bone vibrator outputs.

**0.6** While preparing this standard, assistance has been derived from IEC Pub 118-2 'Methods of measurement of electro-acoustical characteristics of hearing aids: Part 2 Hearing aids with automatic gain control circuits' issued by the International Electrotechnical Commission ( IEC ).

**0.7** In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960\*.

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## **1. SCOPE**

**1.1** This standard ( Part 3 ) specifies uniform methods of measurement for dynamic and static performance characteristics of hearing aids with automatic gain control circuits.

## **2. TERMINOLOGY**

**2.0** For the purpose of this standard, the terms and definitions given in IS : 1885 ( Part 3/Sec 5 )-1966† shall apply in addition to the following.

**2.1 Automatic Gain Control ( AGC )** — A means in a hearing aid by which the gain is automatically controlled as a function of the magnitude of the envelope of the input signal or other signal parameter.

NOTE — Throughout this standard, reference is made to the use of acoustic inputs. However, where appropriate additional measurements may be made with an electromagnetically induced input.

**2.2 Study State Input/Output Graph** — The graph illustrating the output sound pressure level as a function of the input sound pressure level for a specified frequency, both expressed in decibels on identical linear scales ( Fig. 1 ).

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\*Rules for rounding off numerical values ( revised ).

†Electrotechnical vocabulary: Part 3 Acoustics, Section 5 Speech and hearing.



**2.3 Lower AGC Limit or AGC Threshold** — The input sound pressure level which, when applied to the hearing aids, gives a reduction in the gain of  $2 \pm 0.5$  dB with respect to the gain in the linear mode ( Fig. 1 ).

**2.4 Compression Ratio ( Between Specified Input Sound Pressure Level Values )** — Under study state conditions, the ratio of an input sound pressure level difference to the corresponding output sound pressure level difference, both expressed in decibels ( Fig. 1 ).

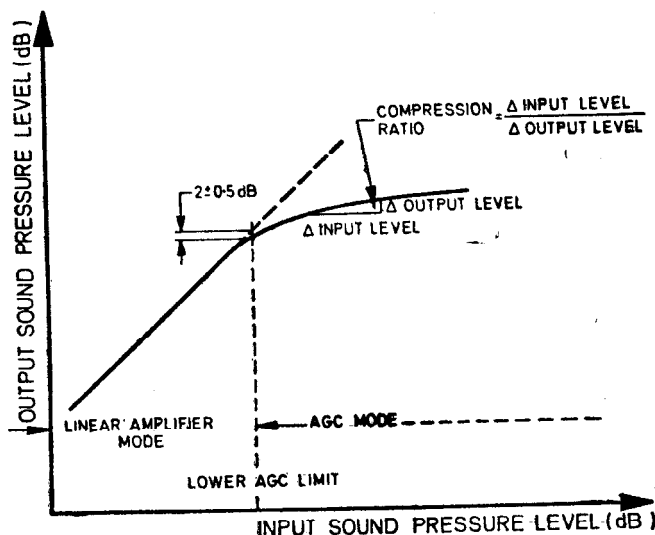


FIG. 1 EXAMPLE OF STEADY STATE INPUT/OUTPUT GRAPH

**2.5 Dynamic Output Characteristics** — The output sound pressure envelope shown as a function of time when an input sound signal of a predetermined frequency and level is modulated by a square envelope pulse with a predetermined pulse amplitude ( Fig. 2 ).

**2.6 Attack Time** — The time interval between the moment when the input signal level is increased abruptly by a stated number of decibels and the moment when the output sound pressure from the hearing aid with the AGC circuit stabilizes at the elevated steady state level within  $\pm 2$  dB ( Fig. 2 ).

**2.6.1 Attack Time for the Normal Dynamic Range of Speech** — The attack time, when the initial input sound pressure level is 55 dB and the increase in input sound pressure level is 25 dB.

**2.6.2 High Level Attack Time** — The attack time, when the initial input sound pressure level is 60 dB and the increase in input sound pressure level is 40 dB.

**2.7 Recovery Time** — The time interval between the moment when the stated input signal level is reduced abruptly to a level a stated number of decibels lower after the AGC amplifier has reached the steady state output under elevated input signal conditions, and the moment when the output sound pressure level from the hearing aid stabilizes again at lower steady state level within  $\pm 2$  dB ( Fig. 2 ).

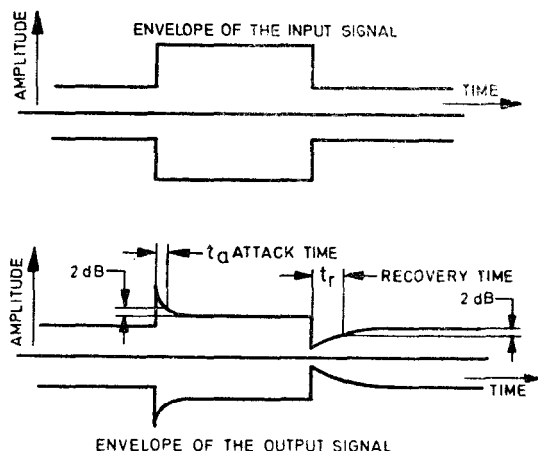


FIG. 2 DYNAMIC OUTPUT CHARACTERISTIC OF AN AGC CIRCUIT

**2.7.1 Recovery Time for the Normal Dynamic Range of Speech** — The recovery time, when the initial input sound pressure level is 80 dB and the decrease in input sound pressure level is 25 dB.

**2.7.2 High Level Recovery Time** — The recovery time, when the initial sound pressure level is 100 dB and the decrease in input sound pressure level is 40 dB.

### 3. CONDITIONS FOR MEASUREMENTS

**3.0** Provisions of 3, 4 and 5 of IS : 10776 ( Part 1 ) \* shall apply in addition to the following.

**3.1** Although a pure-tone input signal of 1 600 Hz or 2 500 Hz when appropriate, is specified for various measurements throughout this standard, it is intended that pure-tone signals of other frequencies or signals of other spectral compositions may be used in addition where they would provide important information.

\*Methods of measurement of electro-acoustical characteristics of hearing aids: Part 1 General measurements for air-condition hearing aids.

## 4. MEASUREMENTS

### 4.1 Steady State Input/Output Graph

**4.1.1** Graph showing the relation between input sound pressure level and output sound pressure level.

**4.1.1.1** The graph shall have the input sound pressure level as abscissa and the output sound pressure level as ordinate, both expressed in decibels on linear scales having divisions of identical size.

NOTE — In the input/output graph of an AGC device, different portions may be distinguished:

Below the lower AGC limit the slope is essentially  $45^\circ$  ( linear amplifier mode ).

Above this limit, the graph curves over in a portion having a decreasing slope, often followed by another portion having a nearly flat slope ( AGC mode ).

At very high input levels, a flat or sloping portion may be followed by a portion with a steeper slope, generally due to saturation of the AGC circuit.

**4.1.2 Methods of Measurement** — The gain control is adjusted to its maximum setting. Any adjustable gain control after the AGC loop shall be adjusted in such a manner that overload of the hearing aid is avoided.

An input sound signal of frequency 1 600 Hz is applied at the lowest possible level consistent with an adequate signal-to-noise ratio of preferably more than 10 dB. The input sound pressure level is increased up to 100 dB in sufficiently small steps, and the corresponding output sound pressure level is measured after steady state conditions have been reached. The graph is plotted with the input sound pressure level as abscissa and the output level as ordinate, as described in **4.1.1**.

Where separate adjustable controls exist, such as AGC, gain or output controls, which will influence the shape and other characteristics of the steady state input/output graph, it is recommended that input/output graphs be plotted, when useful for various additional stated setting of such controls.

### 4.2 Dynamic Output Characteristics

**4.2.1** The purpose of this test is to determine the dynamic characteristics of the AGC circuit, particularly attack and recovery times. It should be emphasized that all these characteristics will depend on test frequency as well as on such factors as signal level, control settings and battery voltage.

#### 4.2.2 Methods of Measurement

**4.2.2.1 Dynamic output characteristics of speech levels** — At the maximum setting of the gain control, an input signal of 1 600 or 2 500 Hz when appropriate with a sound pressure level of 55 dB is applied. Any adjustable gain control after the AGC loop shall be adjusted in such a manner that overload of the hearing aid is avoided.

This signal is modulated by a square envelope pulse raising the input level by 25 dB. The pulse length shall be at least five times longer than the attack time being measured. If more than a single pulse is applied, the interval between the two pulses shall be at least five times the longest recovery time being measured.

NOTE 1 — This test may be carried out at various control settings as stated in 4.1.2.

NOTE 2 — If lower gain control settings are applied, the method of obtaining those settings shall be clearly specified.

NOTE 3 — The loudspeaker employed for the measurement of dynamic output characteristics as in 4.2 must be sufficiently free of transient distortion so that test results are not appreciably affected.

NOTE 4 — The output signal should be monitored on a device such as an oscilloscope, the time constants of which are considerably shorter than those being measured.

NOTE 5 — When very short response times are to be measured, the response time of the source shall be reported.

NOTE 6 — For half-wave rectifying AGC circuits, the attack time is dependent upon the polarity of the first halfwave of the test signal after the onset of the modulating square wave envelope. Depending upon the polarity, a shorter or longer attack time will occur. This is best demonstrated in case of an instantaneous rise in the amplitude occurring at a zero crossing of the test signal.

**4.2.2.2 Dynamic output characteristics for high level input** — At the maximum setting of the gain control an input signal of 1 600 or 2 500 Hz when appropriate with a sound pressure level of 60 dB is applied. Any adjustable gain control after the AGC loop shall be adjusted in such a manner that overload of the hearing aid is avoided. This signal is modulated by a square envelope pulse raising the input level by 40 dB. The pulse length shall be at least five times the attack time observed.

If more than a single pulse is applied, the interval between two pulses should be at least five times the longest recovery time being measured ( see Notes 1 to 6 under 4.2.2.1 ).

#### 4.3 Non-linear Distortion

**4.3.1 Transients** — The signal may be distorted during the attack time and recovery time by transients as well as by unwanted low frequency modulation caused by instabilities. The effect of these phenomena on

the listener is not sufficiently understood to allow a recommendation for measuring transient distortions to be made.

#### **4.3.2 Harmonic Distortion**

**4.3.2.1** The purpose of this test is to determine the harmonic distortion as a function of the input sound pressure level after steady state conditions have been reached.

**4.3.2.2 Methods of measurement** — Provision of **6.12.1** of IS : 10776 ( Part 1 )\* shall apply.

#### **4.3.3 Intermodulation Distortion**

**4.3.3.1** Provision of **6.12.2** of IS : 10776 ( Part 1 )\* shall apply.

### **4.4 Effect on Steady State and Dynamic Performance with Respect to Variation in Battery or Supply Voltage**

**4.4.1** The change in the performance parameters of the characteristics specified in **4.1**, **4.2** and **4.3** shall be tested with respect to variation in battery or supply voltage in accordance with **6.8** of IS : 10776 ( Part 1 )\*.

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\*Methods of measurement of electro-acoustical characteristics of hearing aid:  
Part 1 General measurements for air-condition hearing aids.